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ABSTRACT

Mathematics education is different in rural schools than in non-rural schools. An explanation for this can be found in an open social systems model of schools, in which schools are comprised of interdependent subsystems that function together to transform inputs into outcomes. These are open systems in that external forces in the environment beyond the school influence the internal components of the school, and the school affects the environment in a reciprocal relationship. At the heart of the school is the technical core where the school converts inputs (human resources) into outcomes. This process involves four subsystems. The structural system comprises the organizational hierarchy and the bureaucratic rules and regulations that organize the work of teachers, administrators, and other staff. The political system represents the informal power relationships that occur within schools and can have significant influence on the workings of the organization. The individual system consists of the beliefs and needs of individuals within the system, while the cultural system represents the shared beliefs and expectations of system participants. Characteristics of each subsystem are presented along with research questions relevant to mathematics education in rural schools. Paying attention to all parts of the social system will increase the chances of success for teachers, students, and society as a whole, whereas restricting the focus of improvement to changes in the technical core will slow the amount of time in which change will materialize. (Contains 25 references.) (TD)

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Mathematics Teaching and Learning in Rural Contexts: A Social Systems Perspective

Working Paper No. 5

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Mid-continent Research for Education and Learning
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ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. The project aims to (1) understand the rural context as it pertains to learning and teaching mathematics, (2) articulate in scholarly works, including empirical research, the meaning and utility of that learning and teaching among, for, and by rural people, and (3) improve the professional development of mathematics teachers and leaders in and for rural communities.



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**Mathematics Teaching and Learning in Rural Contexts:
A Social Systems Perspective**

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MATHEMATICS TEACHING AND LEARNING IN RURAL CONTEXTS: A SOCIAL SYSTEMS PERSPECTIVE

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The notion that mathematics teaching and learning is somehow different in rural contexts than in urban and suburban ones is strange to most people. After all, $2 + 2 = 4$ whether you live in Buffalo, New York, or Buffalo, Wisconsin (population 1,040). A triangle has three angles that add up to 180° whether you live in Detroit, Michigan, or Detroit, Texas (population 718). And the square root of 1,936 is still 44 whether you are in Minneapolis, Minnesota, or Minneapolis, North Carolina (population 250). Among those of us who attended or taught in a rural school, however, experience suggests that meaningful differences do exist.

Although much anecdotal evidence exists about these differences, there is not yet a comprehensive body of empirical literature upon which to draw definitive conclusions about the effects of rurality on mathematics teaching and learning. There is, however, substantial research about how organizations function, and that literature can enlighten us about which aspects of rural schools might influence the teaching and learning of mathematics in rural schools. This paper examines some of this research and suggests ways it can be applied to rural schools. The discussion begins with a brief consideration of an *open social systems* model of schools in order to provide a framework for thinking about how the contexts of rural communities and schools might influence student achievement in mathematics.

Schools as Social Systems

Figure 1 illustrates the open systems model selected to illuminate the issues, especially for readers unused to thinking about the organizational contexts of curriculum and instruction. In this model schools are social systems comprised of interdependent subsystems that function together to transform inputs into outcomes. Although they do have recognizable boundaries that separate them from their wider environment, they are *open* rather than *closed* systems. That is, external forces in the environment beyond the school influence the internal components of the school. At the same time, however, the school affects the environment in a reciprocal relationship in which the school relies on the community for the provision of inputs, while the community relies on the school to transform those inputs into something of value (e.g., student achievement).

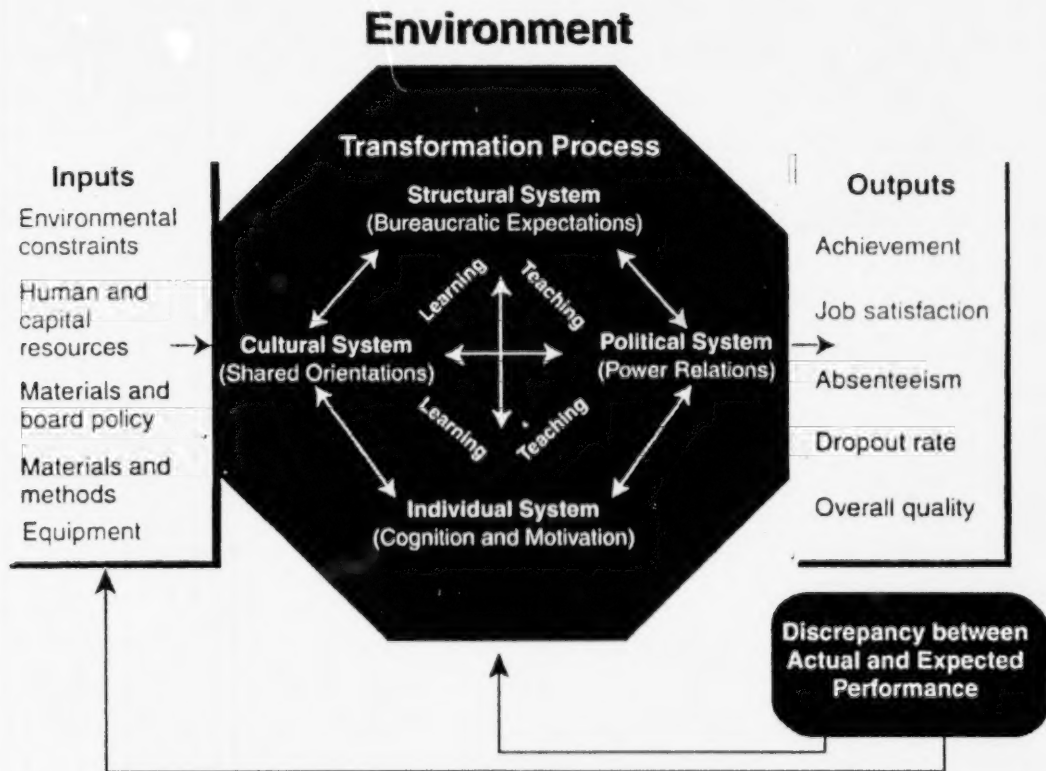
At the heart of the school is a transformation process where the school converts inputs (e.g., human resources) into outcomes. This process involves four subsystems: the structural system, the political system, the individual system, and the cultural system. The *structural* system comprises the organizational hierarchy and the bureaucratic rules and regulations that organize the work of teachers, administrators and other staff. The *political* system represents the informal power relationships that occur within schools that can have significant influence on the workings of the organization. The *individual* system consists of the beliefs and needs of individuals within the system, while the *cultural* system represents the shared beliefs and expectations of participants in the system. These subsystems support the *technical core* of the organization, which is "where the actual 'product' of the organization is produced" (Hoy & Miskel, 2001, p. 40). In the case of schools, the technical core is teaching and learning.

This model provides a framework for thinking about how rurality might affect mathematics teaching and learning. Much attention has been paid to the inputs, outcomes, and technical core aspects of rural schools. The model suggests that attention must also be paid to the subsystems (e.g., the cultural system) of the organization and the environment. These factors can in turn be influenced by each other and by the external environment. The environment can influence the amount and quality of inputs, as well as the perceived importance of different outputs.

From the social systems literature, Hoy and Miskel (2001) gleaned a number of assumptions that underlie this model. These assumptions provide insight into how the elements of rural schools may affect the effectiveness of teachers and the student learning. These assumptions are presented below and have been framed in terms of rural schools.

- Rural schools are open systems affected by the values of the community. They are also influenced by societal and political factors that extend beyond the local community.
- Rural schools are staffed by people who fulfill specific roles and responsibilities. People act in ways that fulfill personal needs and correspond to local culture.

Figure 1: Social systems model of schools



Source: Wayne K. Hoy & Cecil G. Miskel (2001) *Educational Administration: Theory, Research, and Practice*. 6th ed. (p.31)

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- Rural schools consist of interconnected parts that form a system. As such, changes affecting one part of the organization will affect the other parts.
- Rural schools are outcome oriented. As noted in Figure 1, student achievement is only one of many outcomes schools produce.
- Rural schools have structures that ensure that the organization performs needed functions.
- Rural schools have formal and informal rules that direct appropriate behavior.
- Rural schools reward appropriate behavior and punish those that are outside established norms.
- Rural schools are political in that they have informal power relationships that influence behavior.
- Rural schools have distinctive cultures that vary from school to school.

The model helps illustrate the complexities of trying to undertake an effort to cultivate “indigenous leadership capacity for the improvement of school mathematics,” the stated goal of the Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics (ACCLAIM, 2002, p. 1).

Because the parts of the system are interconnected, attention must be paid not only to the *technical core* (i.e., learning, assessment, and instruction), but also to the structural, political, individual, and cultural subsystems. Failure to attend to these systems will predictably have negative consequences. This is the characteristic of social systems that makes for what some refer to as the “wicked” nature of school improvement problems (Lewis, Toole & Hargreaves, 1999). Expertise is insufficient to the task usually assigned to it in school reform efforts. Adding to this challenge is the uncertain influence that external environments impose, an influence that can vary substantially among communities.

The Environment

As mentioned previously, rural schools are interdependent with the environment in which they function. Rural schools not only are affected by influences emanating from the local community but also are influenced by state and national policies, technological developments, economic and social factors, and cultural values. The external environment in which rural schools operate today differs sharply from what it was a few years ago. In recent months *No*

Child Left Behind (the reauthorized Elementary and Secondary Education Act) has created considerable stress among rural educators as they struggle to implement the provisions of the act. Although the intent of the law is to improve educational outcomes for student, concern remains among rural educators and politicians that the new federal policy could harm schools and their communities.

At the same time, rural America is experiencing substantial economic and social changes that have shifted the conventional wisdom about the relationship between education and rural life. Historically, academically talented rural youth often were encouraged by their parents and teachers to stay in school, go to college, and move to the city to find higher paying jobs. The result has been a steady outmigration of the most highly educated from rural areas, making human capital one of the most exported rural resources. Today's rural communities can no longer afford to lose human capital if they wish to survive and thrive.

If, as some observers have suggested, rural America must seek a "new competitive advantage" rather than continue to protect the "old competitive advantage" (Stauber, 2001), then schools must prepare students to drive and maintain enterprises that produce and market the high-value goods and services in demand in today's marketplace. Just as a reliance on low-wage, low-skill jobs in manufacturing will no longer serve rural communities struggling to survive in the 21st century, a reliance on an education that ends with a high school diploma will arguably no longer serve most rural students. Although many jobs in the "new economy" of rural America will not require a bachelor's degree, "the largest share of jobs in the rural economy of the near future will require a level of education beyond high school" (Gibbs, 2000, p. 5).

New technologies require students to learn new skills. The increased use of computer technology in the workplace means an increased demand for individuals with higher-order thinking skills in addition to general work skills. "The increasing need for individuals able to use computers will also raise the payoff to other skills and characteristics that are necessary for or even merely correlated with computer skills – such as mathematical and reasoning skills, education, and patience – even in those jobs that do not require computer use" (Kusmin, 2000, p. 26). Thus, changes in the environment are forcing rural schools to prepare more students for college and other educational opportunities beyond high school. It is also clear that mathematics will be a key content area.

Because it is generally agreed that there is a strong connection between the school and community (Theobald & Nachtigal, 1995), we would expect that there would be strong alignment between community expectations for student learning in mathematics and the curriculum and instruction of the school. At the same time, however, state content standards and assessments – also part of the environment – force rural schools to align their instructional programs with state rather than local expectations. This situation raises serious questions about whether state standards drive out local, placed-based curriculum. Nancy Jennings's research in rural Maine suggests, however, that locally responsive curriculum and state standards can be combined effectively, although with considerable effort (Jennings, 2000).

There are two ways to look at the changing economic, social, political, and educational conditions in rural America. One view is to see these changes as problems that must be overcome or fixed. This view is reminiscent of the negative perceptions of rural schools held by educational reformers through much of the 20th century. The second view is to consider these conditions as creating an environment conducive to expanding the indigenous capacity to

improve mathematics teaching and learning in rural schools. Key to building this capacity is the quality of the inputs that go into the process of schooling – in particular, teachers.

Inputs

As noted in Figure 1, many different types of inputs go into schools. Perhaps none is more important than teachers. We know that teacher quality is one of the most important factors in students learning mathematics, and that students learn more from teachers with both strong pedagogical skills and mathematics content knowledge (Sutton & Krueger, 2002). We also know that we are currently in a period of high teacher demand, particularly in mathematics, and that rural schools often have difficulty competing for teachers because of low pay and factors related to being rural.

Because the demand for teachers is outpacing the supply, rural administrators must pay close attention to retaining good teachers they already have. What does a good mathematics teacher look like? Research suggests that highly effective mathematics teachers:

- have a deep knowledge of subject matter, which enables them to draw on that knowledge with flexibility;
- encourage all students to learn for understanding;
- foster healthy skepticism;
- allow for, recognize, and build on differences in learning styles, multiple intelligences, and abilities;
- carefully align curriculum, assessment, and high standards;
- conduct interim assessments of students' progress and use the results to improve instruction;
- measure instructional effectiveness through student performance and achievement; and
- use a problem-solving approach (Sutton & Krueger, 2002).

In the case of rural schools, I would add to these recommended qualities:

- the need for rural teachers to appreciate the importance of school-community relations (DeYoung, 1987). For instance, the ability and willingness to coach at least one sport is highly desirable.

This list of desirable characteristics suggests that when a rural school or district is blessed with a highly effective mathematics teacher, administrators should do everything that can be reasonably done to keep him or her in the school district. Teachers leave the profession because of job dissatisfaction or interest in pursuing another career (Ingersoll, 1999). Rural teachers face the additional burden of coping with issues that arise from living in geographic isolation. These issues include professional and social isolation, and in some areas, inadequate access to basic health care services (Murphy & Angelski, 1997). A recent article in the *Rocky Mountain News* (Perrault, 2002) reports that "there isn't a single dentist in 12 rural Colorado counties." Even teachers who grew up in the rural locale in which they teach may find these conditions *professionally* challenging.

Professional development is another key factor in building the skills of mathematics teachers. Research indicates that effective professional development must be of adequate duration and provide teachers with the skills and knowledge they need to improve (Sutton & Krueger, 2002, p. 31). Sadly, most professional development consists of short, self-contained workshops that do not contribute to sustained and significant change in teacher practice (Gamoran, Secada, & Marrett, 2000).

Rural schools face a number of challenges in developing effective professional development programs. Small enrollments result in a lack of opportunities to work collaboratively with fellow teachers who teach the same subject or grade. Rural schools also lack the critical mass of financial resources to bring in even modestly priced professional developers. Often rural schools have to rely on the professional development offered by state educational agencies, intermediate educational agencies, and other larger districts. The professional development programs offered by other organizations, however, typically do *not* align with rural school improvement goals, in my experience.

Although there is universal agreement that rural schools need high-quality teachers, there has been little research on how to accomplish this goal (Khattri, Riley, & Kane, 1997). Hence a number of issues need empirical investigation, including the following:

- What does a highly effective mathematics teacher look like in rural schools?
- How do rural schools attract and retain teachers who are, or can become, effective teachers?
- What does effective professional development look like in rural schools?
- How can rural schools get the professional development they need to ensure that every mathematics teacher has the opportunity to be a highly effective teacher?

The Structural System

One argument made for maintaining small, rural schools is that increasing the bureaucratic structures leads to dysfunctional practices. Kannapel & DeYoung (1999) note that the comparative lack of bureaucratic structures in rural communities is a good thing in that it "allows for direct, verbal communications" (p. 69). Although the general view of bureaucracies is negative, the intent of bureaucratic structures is to facilitate the work of the organization.

Hoy and Sweetland (2001) suggest two general types of bureaucracies: enabling and hindering. Enabling bureaucracies :

- foster two-way communication,
- see problems as learning opportunities,
- support differences,
- are open,
- delight in the unexpected,
- easily correct mistakes, and make it easy for participants to do so,
- embrace participative decision making, and
- focus on problem solving (Hoy & Miskel, p. 99).

Hindering bureaucracies are characterized by the opposite qualities:

- one-way, top-down communication,
- a view of problems as constraints,
- forced consensus,
- suspicion of differences,
- watchful mistrust,
- fear of the unexpected,
- punishment for mistakes,
- unilateral decision making, and
- a focus on authority.

It would be convenient if all rural schools were characterized by enabling bureaucratic structures. We know, however, that in reality rural schools can have structures just as inhibiting as non-rural schools. A number of unanswered questions have not yet been researched:

- What specific bureaucratic structures need to be in place to support teaching and learning in mathematics in rural schools?
- Does rurality play a mediating role in hindering bureaucracies?
- What skills to administrators and other leaders need to ensure that schools build enabling structures?

The Political System

The political system of schools comprises the informal power relationships that exist among individuals. It is this system that often resists the efforts of the formal organization to implement change and thus must be attended to in school improvement efforts. Politics are typically informal, frequently illegitimate and often clandestine. In the end, however, politics are virtually impossible to escape in schools (Hoy & Miskel, 2001).

Mintzberg (1983) reports that politics often play themselves out in four major different types of games: insurgency games, power-building games, rival games, and change games.

Insurgency games are used to resist formal authority. They can play themselves out in many ways, ranging from mild resistance to outright mutiny. In a rural school, this game may be used by teachers to sabotage new programs or procedures. Administrators have to decide when and how to exert their formal authority when requests or rules are ignored.

Power-building games are used to build a power base. These games can range from alliance building to empire building. Whichever game is undertaken, the object is build support from others in the organization.

Rival games occur between two or more individuals or groups. The purpose is to have one's goals win over those of another. These games can involve individuals or alliances of people who favor a particular position. Rival games often are divisive, with winners and losers. In rural schools, particularly in rural communities growing due to migration, struggles often occur between newcomers and long-time residents and teachers.

Change games alter an organization or its policies and procedures. Change games can be undertaken by different people in different ways. When important change occurs in an organization, some individuals typically gain while others lose. Alliances form that seek either to implement or to block change.

Political systems are an important, yet often overlooked, aspect of schools. Because rural schools are generally smaller and the connection between the school and the community is strong, their politics can be particularly tricky. In a tightly knit community political games can spill out of the school into the community. Likewise, political issues in the larger environment affect schools and classrooms. Several researchable issues come to mind.

- What political games occur when rural schools implement changes in teaching mathematics?
- Are fewer or more political games played in rural schools?
- What skills should rural school leaders possess to manage the internal and external politics of rural schools?

The Individual System

Individuals who work in rural schools, or any organization for that matter, are motivated by their needs, goals, and beliefs. A central issue that falls under this category is how to motivate teachers to do a good job. Motivation can be thought of as extrinsic or intrinsic.

Extrinsic motivational techniques include merit pay and career ladders. The research on merit pay reveals that it is not a long-term solution to motivating teachers. Smylie and Smart (1990) found that teacher willingness to participate in a merit pay program depends on how they see it affecting their relationships with other teachers. Research also indicates that merit pay systems are generally short-lived. Career ladders are another approach to motivating teachers. The research on the effectiveness of career ladders is mixed. When implemented appropriately, they can demonstrate positive effects.

The individual system will play an important role in improving mathematics teaching and learning. Questions remain, however, as follows:

- What will motivate teachers to pursue innovative methods to link their instruction with the local context?
- How can small rural schools effectively motivate teachers?
- What factors motivate teachers to stay in rural schools?

The Cultural System

The cultural system of a school comprises the organization's shared norms and expectations. The norms and expectations reflect core values, the dominant opinions shared by the majority of the group. In rural schools we would expect to find considerable alignment between the cultural values of the school and the community. Sometimes other factors in the external environment – state and federal education policies, for example – can conflict with those values. There are also instances when cultural differences found in the community play themselves out in schools.

Referring back to the model in Figure 1, the cultural system of a rural school influences the structural, political, and individual systems as well as the technical core. Therefore, an important question is, what does a culture that facilitates good math instruction look like in rural schools?

Deal (1985) argues that effective schools have the following cultural characteristics:

- shared values and a consensus on "how we get things done around here,"

- a view of the principal as a hero or heroine who embodies core values,
- distinctive rituals that embody widely shared beliefs,
- a view of employees as situational heroes or heroines,
- rituals of acculturation and cultural renewal,
- significant rituals to celebrate and transform core values,
- balance between innovation and tradition and between autonomy and control, and
- widespread participation in cultural rituals.

Deal's perspective leads us to the following research questions:

- What are the cultural characteristics of effective rural schools?
- Are there specific cultural aspects found in rural schools that would enable or hinder efforts to improve mathematics achievement?
- How can the administrators and leaders influence aspects of local cultures to facilitate mathematics achievement?

The Technical Core

As noted earlier, the technical core of an organization is "the system of organizational activity where the actual 'product' of the organization is produced" (Hoy & Miskel, p. 40). In schools, teaching and learning is the technical core. Research on instructional strategies provides a pretty clear picture of effective instructional practices. Marzano (1998) conducted a meta-analysis of more than 100 studies that examined specific instructional strategies. His results point to nine instructional strategies that are effective regardless of the instructional goals:

- When presenting new knowledge or processes to students, first provide them with advanced ways of thinking about the new knowledge or processes.
- When presenting students with new knowledge or processes, help them identify what they already know about the topic.
- When students have been presented with new knowledge or processes, have them compare and contrast it with other knowledge and processes.

- Help students represent new knowledge and processes in nonlinguistic ways as well as linguistic ways.
- Have students use what they have learned by engaging them in tasks that involve experimental inquiry, problem solving, decision-making, and investigation.
- Provide students with explicit instructional goals and give them explicit and precise feedback relative to how well those goals are met.
- Praise and reward students when they meet an instructional goal.
- Have students identify their own instructional goals, develop strategies to obtain their goals, and monitor their own progress and thinking relative to those goals.
- When presenting new knowledge or processes, help students analyze their beliefs that will enhance or inhibit their chances of learning the material. (p. 134-135).

At this point, two questions are pertinent.. First, are some of these instructional practices more effective than others in teaching mathematics? Second, are some instructional practices more effective for rural students? The importance of these questions is illustrated through an example from science teaching. Van Secker and Lissitz (1999) conducted a study of the effects of three instructional strategies recommended by the National Science Education Standard (National Research Council, 1996) on student science achievement. The three strategies were (a) student-centered instruction, (b) teaching of critical thinking skills, and (c) use of "hands-on" laboratory activities. Van Secker and Lissitz found that emphasizing student-centered instruction increased the differences in science achievement between boys and girls. Similarly, emphasizing critical thinking created a greater achievement gap between high and low socioeconomic status students. Marzano, Pickering and Pollock (2001) suggest that there needs to be further investigation into "the effects of instructional strategies, with specific types of students in specific situations, with specific subject matters" (p. 9).

Conclusion

This paper began with an assertion – that mathematics teaching and learning is different in rural schools than in non-rural schools. This assertion receives support from the discussion that followed, which illustrated the literature on organizational theory that shows that we should expect certain kinds of differences that emanate from the environment. Indeed, this influence is so extensive that it affects every part of the system – from the inputs through the organizational subsystems to the final outcomes. Not only should we expect teaching and learning in rural schools to be different, to expect otherwise must be regarded as illogical.

One of the challenges of working with rural schools is being able to explain how they differ from urban and suburban schools. Those in the field generally accept that such differences arise from their "size, the scale on which education takes place, their isolation from one another, and from the infrastructures of support present in more populated areas" (Haas, 1991, 419). In contrast to other fields, there is not a substantial body of research to inform our understanding of how these differences affect the classroom. Imagine having 100 studies, as Marzano (1998) did in his study of effective instructional strategies, available for a meta-analysis of the effects of rurality on teaching and learning in rural schools.

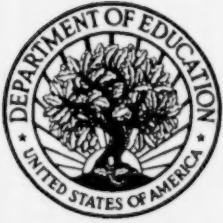
The challenge before us is clear. We must increase the amount of high-quality research that investigates the rural phenomenon in schools. To accomplish this goal, we must first focus on the issue of what effective education looks like in rural contexts. We must stop producing research aimed specifically at proving that small rural schools and districts are more effective than large rural schools and districts. We should operate under the realization that some small rural schools are good and some are bad. Our focus should be on how to ensure that all children living in rural America can receive an education allowing them to live healthy and productive lives, whether they choose to stay in their rural community or move elsewhere.

Finally, there is a more important issue. Simply because the environment does influence the work of organizations, we should ensure that teaching and learning mathematics in rural schools be different in *meaningful* ways – different, that is, not just by happenstance, but different in the name of helping students to better understand mathematics concepts and to apply them to their *lives in rural places*. This is hardly an unfamiliar idea, in fact, among mathematics educators. For instance, according to Sutton and Krueger (2002, p. 58), "children learn both inside and outside the classroom" and therefore "it is the primary responsibility of the mathematics teacher to connect these two realms of knowledge and use those connections to augment understanding of both worlds." Helping teachers develop the instructional skills to make those connections will, many believe, improve student learning in mathematics. By contrast, restricting the focus of improvement to changes in the technical core will predictably slow the amount of time in which significant changes in instruction materialize widely. Paying attention to all the parts of the social system will increase the chances of success for teachers, students, and society as a whole.

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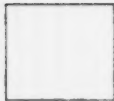


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